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SURVEYS AND MAPS FOR PIPELINES

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SURVEYING AND MAPPING
DIVISION

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SURVEYS AND MAPS FOR PIPELINES

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Introduction

Since its inception, the petroleum industry has relied heavily on survey and mapping techniques. Exploring for new oil or gas fields and the development of unproven reserves have constantly kept geological field parties traversing and mapping the remote corners of the world. The development of the airborne magnetometer was largely due to the exploratory requirements of the petroleum industry and aerial photography has been a significant factor in reducing the mapping efforts formerly conducted by geologists.

As the petroleum industry expanded and developed, the need for economical transportation of its products to its markets, soon led to the advent of long range, "big inch" pipelines as a means of transportation. The subsequent growth of the pipeline as an economical means of mass transportation has been a rapid modern day revolution.

The office of Petroleum Administration for Defense estimates that about 163,000 miles of petroleum pipe lines were in operation within the United States as of January 1, 1953, and an additional 10,000 miles are expected to be placed in operation this year. The natural gas industries expansion of operating transmission pipe lines has been no less rapid. The American Gas Association reports that from 1936 to 1951 the miles of transmission lines operating in the United States increased from 55,000 to 118,000.

Though the oil and gas industries are the undisputed giants of cross-country pipelines, the ultimate uses of pipelines as a means of mass transportation give wide range to the imagination.

Successful tests have already been made by Pittsburgh Consolidated Coal Company on shipping coal by pipeline. Though still in a development stage, the piped coal is finely crushed, immersed in water and forced by pressure pumps through the pipeline. It was estimated that such a line from Cadiz, Ohio, to Lake Erie, a distance of over 100 miles, might conceivably deliver coal for $1.00 a ton less than rail fare, the current rail rate being about $2.75 a ton.

Like railroads, airlines, and bus lines, long distance big-inch pipelines are regulated by governmental bodies in the best interests of the public as a whole. For this reason, an application to the Federal Power Commission for a permit to construct a pipeline must be accompanied by a wealth of information regarding costs, design and proposed rates.

In the regulating of permits, consideration is given such factors as fair return to producers, avoidance of injurious competition to established utilities, meeting present and future demands, the withdrawal rates from wells in accordance with sound conservation practice, evidence of long-term contracts with suppliers and distributors, and assurance that the entire project is on a sound financial basis.

There may be several competing entrepreneurs for permission to construct a pipeline and approval is usually given to the one best meeting the above requirements with weight given to the lowest sales price to the public.

All the above requires great ingenuity and skill on the part of the planners and designers to choose the best combination of pipe size, pumps and compressors for economy.

The entire development of the pipeline industry was, of course, based on the fundamental fact that this was the most economical means of transporting great volumes of fluid products. Such economic transportation not only depends upon the operating costs of the system but also upon the initial construction costs. Each of these factors must be borne in mind when locating a pipeline, and consequently the location survey may be considered the most important of the several types of surveys attendant to pipeline construction.

Route Selection

The three prime requisites for the economic location of a pipe line are:

1. Obtain the shortest practicable route from end to end.
2. Avoid extreme differences in elevation.
3. Provide access for both construction and maintenance.

Pipelines are cross-country transportation facilities, linking North with South, East with West, crossing major rivers and mountain ranges; and presenting a foremost example of man's vision and initiative. They are first studied on small-scale maps showing all or a great portion of the continent. Here, based upon supply and demand studies, and controlled by such major topographical features as mountain passes, feasible river crossings, the Great Lakes, the Pre-Cambrian shield and governed by national boundaries, the pipeline is laid out.

In connection with the route selection it might be well to point out some essential differences between pipelines and other transport facilities. The first is that all flow in a pipeline is one-way; as opposed to usual rail, highway and water routes. The second is that no "containers" such as railroad cars, highway trucks, or ship's holds are used. These latter must always be returned to the point of origin for a new load. If returned empty it is expensive. Hence the tendency is to try for revenue traffic on the return trip, even to the point of offering bargain rates to attract traffic. This in turn leads to influencing the route location by looking for interchange traffic. That is, it will often be considered desirable to deviate considerably from the most direct route if return or interchange traffic is so produced. Pipelines, on the contrary, have no interest in, or need to deviate from the direct route. Hence, the general rule for large pipelines is that the most direct route connecting suppliers and consumers is the best route. This will be tempered by location of mountain passes, transport of construction materials, and access for maintenance and operation.

Another important consideration for the pipeline locator is the comparative independence from adherence to any grade, as compared with a railroad, highway or canal. Once the controlling elevations and length have been established, the mechanical staff prepare a hydraulic gradient which safely clears the control points. From then on the pipeline locator has only to keep his grade below the hydraulic gradient. Minor terrain variations are of no significance, except as construction problems. A pipeline goes over a hill, no expensive cuts or tunnels are involved. Hence lengthening of the line to develop distance to meet gradient requirements, or to avoid excessive earthwork, is unnecessary.

The selection of the general route of a pipeline is usually based on information provided by existing maps and statistics, supplemented by aerial and

ground reconnaissance. Available sources include the United States Army Map Service, publishing a range of maps with scales from 1:1,000,000 up to 1:25,000; the United States Geological Survey quad sheets; the United States Geological Survey geological reports; the Production and Marketing Administration library of aerial photos; state and county highway department maps; the Corps of Engineers charts of navigable streams; United States census reports on population; and Federal Power Commission Statistics on power consumption.

This first phase of the route selection serves only to determine the major obstacles which must be contended with or avoided. The detailed study of all existing maps and charts in the vicinity of the contemplated pipeline route, combined with ground and air reconnaissance, enables the establishment of the general route.

1. Route Maps

First, route maps are made up to show the area through which the pipeline will go. The set of route maps is compiled from existing State Highway Maps and is usually to a scale of 1" = 1 mile. This is accomplished by a lay-down of the pertinent portions of the Highway Maps after each has been photographically reduced or enlarged to the desired scale. The entire lay-down covering a strip approximately 15 miles wide is then photographically reproduced on a transparency. The purpose of these maps is to show the access roads, railroad network and political and public land subdivisions in the vicinity. The proposed route is not placed on this set of route maps until the more detailed route selection is completed as described below.

Location Surveys

Once the preliminary planning, source and market studies, including general route selection, financing, and charter and permission to construct have been completed, the next step is the more detailed location of the proposed line.

Modern pipelines are characterized by astoundingly accelerated construction schedules, in keeping with the general temperament of the oil and gas world, and of pipeliners in particular. Perhaps one of the foremost examples is the Lakehead Pipeline Extension under construction from Superior, Wisconsin, to Sarnia, Canada, a distance of some 630 miles. Mapping and surveys were started January 1953, and completed in July of that year; construction started in April and is to be completed in November of the same year. Cost is in the order of 90 million dollars. Included is a four mile underwater crossing of the Straits of Mackinac, with maximum depth of 240 feet. Truly an astounding feat when it is considered that in this brief period surveys had to be made, special legislation passed, right-of-way acquired, pipe bought, rolled, and delivered, construction contracts let, and all co-ordinated for completion on schedule.

These accelerated construction schedules are inspired by sound financial reasoning. Money invested in a project must be paid for by interest charges. An uncompleted project is earning no income with which to amortize the investment and pay a profit to the stock holders.

As maps and surveys are an indispensible preliminary to construction, the need for their rapid and punctual production is evident if pipelines are to be completed on schedule.

The science and art of pipeline location has been evolving rapidly in the last ten years. Typical of earlier procedure, after the general route had been decided upon, was to arm a pipeline engineer with the existing maps available and to send him out to "flag" the route. He was fortunate if he had aerial photographs. By "flagging" is meant selecting good road and railroad crossings. The object was for the locators to run the pipeline between these flags. Although many thousands of miles of pipeline have been so located, the method has serious disadvantages. Little was known of the terrain between flags, good, bad, cheap or expensive. The right-of-way agent had little real information on property crossed by the line between roads. He was often unable to contact property owners and secure easement options before the arrival of the surveyors, thus complicating access for survey. Perhaps more important, until actual completion of the survey, no one had a map of the complete line in any detail whatever. This made realistic estimating near impossible. Moreover, the pipeline maps had to be compiled from the surveyors field notes. As a result, strip maps were seldom available for purchase of right-of-way or for construction planning, just when they would have been of most use.

The first great improvement in location procedure was the use of a special set of aerial photos, flown along the route of the proposed pipeline. Typical scale would be one inch equals one-quarter mile, and the photos would cover about 2-1/4 miles of width. Using these, better control of the location was possible. The project's top engineers could view and locate the entire route in the office. The principal resulting advantage was the location to controlled standards of the pipeline engineers, rather than the heterogenous ides of different locators, each covering perhaps 30-50 miles of line.

Aerial photos alone also furnish valuable preliminary information, including probable length of line, amount of clearing, comparative value of lands crossed (high or low-grade farm, pasture, waste) main and secondary access routes to the line. In addition, a good photo-geologist can aid the locator by outlining areas of rock outcrop and probable areas where ledge rock would be encountered above normal ditch level. When it is considered that the extra cost of rock excavation may be from $6 to $12 per lineal foot, or $30,000 to $60,000 per mile, depending on pipe size and class of rock, the value of savings afforded by fullest use of aerial photos is apparent.

Recent years have seen an extension of pipeline construction to a high degree through the northern states and also in Canada. The severe winters encountered introduce a complicating factor in the surveying and construction scheduling. Although, to meet construction schedules, surveys have been started during the winter, it is generally a frustrating and unsatisfactory operation. Days are short, cold is severe, snow is deep, travel is slow and uncertain, and progress is slow and expensive. The snow mantle conceals many terrain features which would normally influence location. If the locator is working from aerial photographs the changed aspect of the country makes orientation difficult.

To overcome or eliminate some of these difficulties a new approach to the surveying and mapping problem of pipelines has been recently developed.

Nevertheless, the land acquisition, field survey, and final route mapping procedures still vary considerably in detail throughout the industry. The Lakehead Pipeline Extension, heretofore mentioned, is a good example of the application of most survey methods to the pipeline industry. This 30" crude oil line took advantage of the lessons and experiences learned throughout the industry and encompassed them into a positive procedure which produced a very efficient location survey.

After the general route selection, the recommended procedure can best be divided into five definite steps as follows:

1. Aerial Photography

Photography of the general route is taken with a 6" cartographic camera from an altitude of approximately 10,000 feet above mean terrain, producing a set of 9" x 9" contact prints covering a strip about 3 miles wide. The camera and altitude may be varied to yield a larger scale photograph of congested or built up areas if necessary. Generally, however, it has been found that a photographic scale of about 1" = 1600' is suitable for pipeline work and facilitates mapping at a scale of 1" = 1000'.

2. Study of Critical Area

The film is processed and a detailed stereo study of the photography is made under the Multiplex or Kelsh projector. This study by experienced pipeline engineers pin-points the location of difficult crossings such as rivers, canyons or populated areas.

3. Stereo-compilation

Topographic mapping of the 2-1/4 mile strip of the entire route at a scale of 1" = 1000' is started in stereo-plotting machines. Existing horizontal control is used in the development of these maps. In areas where there is no existing control, it must be established by field parties.

Normally, no contours are shown on these strip maps, but in extremely rugged terrain where there is a scarcity of planimetric detail relative contouring may be shown for field orientation purposes.

While the photographs are in these machines, pipeline locators are able to study especially difficult terrain in a three dimensional view and select the detailed location between the control points previously selected. Geological interpretation of the photographs are also made at this time to determine areas where surface rock structures should be avoided. The topographic maps produced in the stereoplotting equipment show all planimetric detail in its true relationship. That is, houses, trees, pole lines, streams, ditches, fence lines, clearings, crop lines, highways, railroads, etc., are truly located on the strip map prior to any field work.

On this same map the specific location is then projected so that in essence, a complete set of "final" maps of the location survey can be delivered prior to any line stakeout.

Where there is sufficient existing vertical control or where it can be economically established, an accurate profile of the selected route can also be made by the stereoplotting machines and placed on the strip maps.

4. Stake Out Survey

Field stake out is then started. As the line survey progresses, stakes are placed at even 200 feet stations along the centerline, and all angle points are referenced so that the centerline may be re-established after the clearing and grading operations. All necessary property ties and astronomic observations are made to ensure the positive position of the centerline. With a full set of route maps, photographs, and detailed strip maps showing the proposed location a minimum of decisions is left to the Party Chiefs.

5. Final Mapping

Final mapping proceeds immediately after the survey notes are sent to the job site drafting offices. This step includes the plotting of the field traverse on the original strip map as well as the stationing of all physical features crossed by the pipeline. At this time, the property lines of all parcels traversed are also plotted from the Title Search descriptions supplied by the Right-of-Way Department.

The final strip map is scalable, and shows all the background information as previously described as well as the Tract Numbers or property owners' names and the roddage or acreage of easement taken across his property.

The above procedure has provided economies, not so much in the actual cost of survey, but rather in the organization, planning and administration of a pipeline project. Of these economies the following advantages are salient:

1. The detailed location is made by competent pipeline engineers in the office with a three dimensional view of the terrain in front of them. This enables them to select a route which will require a minimum of field revision, and allows them to pre-determine those areas which might require field location.

2. The stereo-compilation of strip maps prior to the field stake out, provides a complete set of maps with which the Right-of-Way Department can immediately begin to procure lands. This results in a substantial saving in time and money by narrowing the usual swath of options and abstracts normally secured by the Right-of-Way Department.

3. The accurate projection of the selected route on the strip map provides a sound basis for the immediate obtention of clearing permits from governmental agencies, such as State and National Forest Lands.

4. With a two man party sent out in advance of the centerline stake out all highway and railroad cross sectioning information can be rapidly acquired and permit drawings for such crossings can be completed and application made, far in advance of survey.

5. Ground survey can be accomplished more efficiently because:

   A. All right-of-way has been permitted in advance.
   B. Trial survey lines are eliminated since the survey party need only follow the projected route.
   C. Survey can be scheduled for favorable weather without delaying office design or right-of-way obtention.

6. The accurate planimetric map first produced can be used by the designers, right-of-way men, strip map draftsmen, contractors and field survey crews without the confusion attendant to the use of a miscellaneous collection of photos, State and County maps, road maps, geological maps, etc.

Land Acquisition

When the location of a pipeline has been projected, the surveyor must not only stake the line for the constructor's guidance, but also determine the properties crossed and the relation of the right-of-way to the land boundaries.

Pipeline companies similar to other utilities must perforce obtain permission and purchase the right to construct and maintain the line across government or privately owned lands. Obviously this must be accomplished prior to construction to eliminate subsequent costly litigation and damages for trespass and unlawful possession. To attain this right as quickly as possible, close coordination is therefore maintained between the Surveys and Right-of-Way Departments.

1. Easements

In the United States a limited right to construct and operate a pipeline across properties is generally acquired in the form of an easement. Only those lands to be occuppied by pump stations, tank farms or other substantial permanent facilities are purchased in fee. The so called floating easement is most frequently used. As the name implies, the right-of-way is not definitely located or fixed within the property it affects but can be anywhere until fixed by the pipeline as constructed. Easements of this type constituting a private agreement between the company and property owners are acceptable to and registerable in the majority of Land Registry Offices without an accompanying plat or right-of-way map. Obviously this type of easement precludes the necessity of the surveyor obtaining accurate property ties prior to construction. Few States have right-of-way survey requirement laws establishing precision, monumentation and mapping standards. It is left to the surveyor's judgment to decide the survey precision and procedure which best serves the purpose with minimum expenditure of time and money. Generally, pipeline surveys are to the accuracy of 1:2,000 in rural areas and 1:5,000 or better in urban areas.

With the knowledge of the approximate location of the pipeline all available land subdivision maps of properties along the proposed route are obtained; plats of the original subdivision of Public Lands from the General Land Office or State Offices; boundary maps of the State and Federal Forest Lands from the State Department of Conservation; maps of Indian Reservations from the Department of Indian Affairs; subdivision and individual property plats from the Land Registry Offices; highway right-of-way maps from the State and County Departments of Highways; utility companies and railroad right-of-way maps; tax maps and municipal street layout maps.

In connection with the obtention of easement on property to be crossed it is of interest to compare old and new methods. In the early days of pipeline location, right-of-way agents would accompany the survey crews and contact resident owners as the survey proceeded. From information of property ownership thus gained and supplemented by searches in the Land Registry Offices, entry permits and options were acquired. Lacking a predetermined line location, the negotiations for these rights could only be accomplished for a few parcels ahead of the line crew. With the advent of aerial photo strip mosaics, usually to the scale of 1"=1,000', and with the approximate route plotted thereon, property outline maps could be prepared for the right-of-way acquisition use. In sectionalized country developed by farming, and even in the older portions of the United States where properties are irregularly shaped, the visual identification of boundary lines as evidenced by crop and tree lines, fences and roads can be proven when compared with the deed description. The property outlines map developed from the mosaic enabled time consuming acquisition negotiations to be finished before field survey operations. The development of the planimetric map by photogrammetric methods eliminated the scale differences usually inherent in uncontrolled mosaics and further aided the identification and plotting of property outlines.

2. Property Ties

As the field survey proceeds the plus station of all physically evident property lines at the point of intersection with the line are determined and the distance to the nearest property corner is measured. Unless specifically requested by the pipeline company, the right-of-way lines are not monumented.

These property measurements are incorporated on the strip map with other topographic details along the line. Where properties are not physically evidenced by possession the crossing location is calculated. Strip maps normally plotted to the scale 1"=1,000' are primarily made for the use of the constructors and for the acquisition of right-of-way. They are not registered with the easement document.

3. Special Surveys

Individual land owners often demand that the right-of-way be accurately located within their property. In the absence of conclusive monumentation evidence of the boundary line, a land surveyor re-establishes the line to eliminate possibility of encroachment and dispute.

4. Condemnation Surveys

Continued owner opposition to the pipeline crossing occasionally occurs forcing the company as a last resort to make application to the courts for condemnation. For this purpose an accurate survey and plat are made by a licensed land surveyor and are called condemnation surveys. Special surveys of this kind are necessarily more detailed and performed with a precision commensurate with the locality and standard practice.

5. Crossing Permits

Pipeline crossings of highways, railroads, other utilities and navigable streams or rivers also require special surveys and mapping for permit obtention prior to construction.

A profile of the ground surface and the location of fences, ditches, shoulders, edges and type of road pavement, railroad tracks, overhead and underground utilities and the right-of-way lines of the facility crossed are determined, along the center line of the proposed pipeline. Profile elevations are secured for a sufficient distance on each side of the crossing to enable design of pipe bends for required depth and clearance of pipe beneath the facility crossed. The angle of crossing and the location of the crossing with respect to railroad mile post, other intersecting highway or section line is obtained. In the case of highway or railroad crossings the level datum is assumed and normally need not refer to an established datum. Profile elevations of navigable streams under jurisdiction of the Corps of Engineers must refer to local mean low water datum and indicate its relation to mean sea level datum.

The Corps of Engineers has established requirements indicating the information to be shown on the map accompanying the crossing application. This includes: plan and profile showing diameter and thickness of pipe and casing, depth of pipe below river bottom and channel, direction of current, mean low and mean high water lines, the relation of the pipe to the properties on both sides and immediately adjacent to the river, the names of and the consent of the owners of these properties to the crossing of their lands, the distance of the crossing from an existing bridge, location of shut off valves, true bearing of the pipeline and ties to existing horizontal control monuments. Maps of minor crossings are usually plotted on approximately letter size (8-1/2 x 11") tracings and vary in scale depending on the overall length of the crossing.

Acquisition Variations

It is interesting to note the range of land survey requirements for pipeline right-of-way, as established in Canada. Survey and mapping requirements are defined in the Dominion Land Act, the Official Surveys Act and the Land Registry Act and administered by the Surveyor General and the Land Registrars. The floating easement is not accepted for registration. In British Columbia, for example, an easement acceptable to the Land Registrar must contain a metes and bounds description accompanied by a right-of-way map delineating the strip to be taken and accurately locating its position within the property crossed.

Land survey accuracies are specified, of the order: 1:3,000 in undeveloped Crown Lands and 1:5,000 in urban and developed outlying areas. Intersections of one side of the right-of-way with all property lines are marked by iron bars and marker posts. Both corner survey posts of a lot line are recovered and the line between them re-run and measured to insure positive intersection with the pipeline right-of-way. Where property corner monumentation has been lost, the surveyor is required to re-establish the corner from adjoining property survey posts.

The Acts further require that right-of-way surveys and maps be made under the supervision and signature of licensed Provincial or Dominion Land Surveyors.

Maps for registration are prepared in ink on tracing cloth to the scales: 1"=400' for the areas and 1"=200' in the urban areas or to larger scales as requested by the Registrar. They show: the boundary lines and dimensions of the properties crossed by the line; the width dimensions and true bearings of each of the courses of the right-of-way strip; the area of the right-of-way strip to be acquired in each property; the tie measurements and lot line bearing to the property corners; the monumentation set at changes of direction in the right-of-way and intersections with lot lines; the monumentation re-established at lost property corners; and the file number of registered maps pertaining to the properties crossed by the line.

The British Columbia pipeline right-of-way surveys under these high standards have proven to be from four to five times more costly than similar surveys in the United States.

Construction Surveys

Pipeline construction surveys are not as detailed and varies as those necessary for highways or railroads. The need for the majority of these surveys is eliminated since a pipeline can conform very closely to the undulations of the existing terrain without adherence to predetermined grades. In addition, it can go around obstacles if necessary with a minimum radius of curvature as small as twenty-five pipe diameters.

This extreme flexibility makes the usual grade stake out surveys unnecessary. Excepting crossings and where the line is laid within or immediately adjacent to highways and streets, grading is largely left to the judgment of construction foremen. The primary purpose of grading is to smooth out irregularities in the ground surface and provide a working road for construction equipment and future maintenance access. The pipeline cannot be laid in fills.

Not including the normal construction surveys at pump stations, tank farms and other substantial installations, the construction surveys along a pipeline involve:

1. Establishing clearing limits.
   From the staked center line set by the location survey measurements are made to the edges of clearing.
2. Replacing destroyed alignment.
   To provide line for the ditching, the original location stakes where destroyed by farmers' cultivation or cleaning and grading operations are re-established from the references set by the location survey.
3. Line and grade at crossings.
   Line and grade is furnished as needed at major highways, railroads and river crossings to build the pipeline as designed.
4. Pipe bends.
   The horizontal and vertical curvatures of the excavated ditch are determined for field pipe bending.
5. Progress estimates.
   Measurements are made to determine volume of work performed as basis for periodic payments to contractors.

Record Survey

Frequently called an inventory or completion survey, the data obtained by a survey of the completed line provides the physical inventory and location of materials, installations and appurtenances including the final route of the pipeline. Though the line is usually constructed as established by the location survey and construction plans, changes do occur. During construction engineers may discover places where it is economical to change the alignment to avoid underlying rock or swamps. Again, alignment revisions may be made to by-pass certain properties or place it in a location more acceptable to the owner.

The purpose of the record survey is to determine the changes in location and deviations from the construction plans and to provide final maps and plans of the line as constructed.

The survey consists primarily of:

1. Rechain of the line with the chain pulled tight along the surface of the ground or top of pipe if exposed. Office conversion of partial stationing to continuous stationing. This enables establishment of continuous mile post markers in the field for maintenance and operations.
2. Determination of deflection angle at all side bends.
3. Location of all appurtenances to the pipeline.
4. Checking and recording deviations of these appurtenances from the construction plans.
5. Locating changes of pipe wall thickness.
6. Determination of profile elevations, clearances and location of valves, vents, casings and headers at highway, railroad or river crossings.
7. Location of rock cuts, culture and wooded areas.

Record survey maps and plans serve as a guide to maintenance and operations purposes. In addition they constitute a substantiation of the construction costs and are submitted to the Interstate Commerce Commission for consideration as a factor in determining the proposed rates.

One of the most extensive inventory surveys was made for the "Big Inch" and "Little Inch" pipelines built during World War II. The war emergency required that these lines be constructed and put into operation in the shortest time possible. As a result there were a great number of changes in alignment and construction. In order to save time the engineers had to make rapid decisions in the field. Such equipment as pumps, motors and building materials

specified for one pump station would be used at another site in order to expedite completion.

A complete re-survey in detail of the line and installations was made, and all maps and plans redrawn to be in agreement. This included all mechanical, electrical, structural and architectural drawings.

Conclusion

Pipelines are primarily conceived as profit making investments. Once the decision to construct has been made and money invested the object is to complete construction and get them on a paying basis. Speed of survey is indispensable.

They are first studied on small-scale maps showing all or a great portion of the continent. Here, based upon supply and demand studies, and controlled by major topographical features, the general route of the pipeline is laid out. Benefit is then taken of all those medium and small-scale maps available from governmental sources, by means of which the route, with its minor alternates, can usually be narrowed down to about a two mile path. At this stage a field reconnaissance by auto and light plane is usually made. If satisfied as to the construction feasibility of the route an aerial survey is the next step. From here methods may vary. The best practice is to compile planimetric strip maps from the aerial photos. On these the route is projected, aided by photo interpretation, usually in pencil. Prints are distributed to all concerned, engineering, legal, R.O.W., and survey. There is no confusion as would be attendant upon the use of a miscellany of maps by the different departments. No matter what the season of the year the right-of-way people can secure their easement options without waiting for surveys. If in winter, survey activity can be concentrated upon the detail surveys and plans, so-called "permit drawings", needed for the crossings of roads, railroads, canals, and rivers. When the weather moderates the surveyors may proceed with the staking of the center-line and such monumentation as may be required. In the meantime, engineering has had the essential information of length and location of line, elevation of control points, and if needed, a profile of the route, necessary for design of pipe sizes, location of pump or compressor stations, and such auxiliaries as valve and scraper traps. As the center-line is staked in the field the exact location is plotted on the strip maps and the preliminary pencil removed. If in an area where stringent legal requirements specify monumented title surveys tied to existing surveys as a prerequisite to registry of easements, these are made by licensed land-surveyors following the staked center-line.

Surveys and maps used in the location and construction of pipelines range from general area maps at scale 1:5,000,000 down to title surveys, scale 1:1,200 to permit drawings perhaps 1:240. Use is made of the work of those long gone as well as those on hand, all combined with the efforts of promotors and constructors to move gas and oil the thousand of miles from producing to consuming centers.

PROCEEDINGS-SEPARATES

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The technical papers published in the current calendar year are presented below. Technical division sponsorship is indicated by an abbreviation at the end of each Separate Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways (WW) divisions. For titles and order coupons, refer to the appropriate issue of "Civil Engineering."

JANUARY: 379(SM),[a] 380(HY), 381(HY), 382(HY), 383(HY), 384(HY),[a] 385(SM), 386(SM), 387(EM), 388(SA), 389(SU),[a] 390(HY), 391(IR),[a] 392(SA), 393(SU), 394(AT), 395(SA),[a] 396(EM),[a] 397(ST).[a]

[a]Discussions grouped by Divisions.

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